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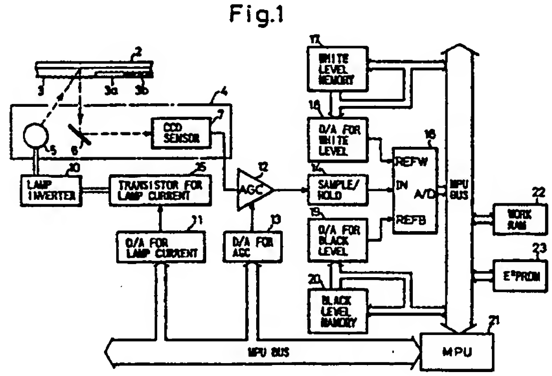
(54) An image scanner having image correcting function

(57) In a calibration phase of image scanning apparatus, an image reading unit (4) is used to perform a first comparison scanning operation in which a reference document is scanned using a flat-bed (FB) technique, and to perform a second comparison scanning operation in which the same reference document is scanned using an automatic-document-feeding (ADF) technique. An image signal (A) representing a predetermined comparison pixel of the image as scanned in the first comparison scanning operation is compared with an image signal (B) representing that pixel of the image as scanned in the second comparison scanning operation. Image correction information, derived from the results of the comparison of the two image signals (A, B) for the comparison pixel, is then stored. Following the calibration phase, when the apparatus is performing a scanning operation of the ADF type image signals derived in that operation are adjusted in dependence upon the stored image correction information so as to reduce differences between those image signals and th⁻ imag⁻ signals that would have been derived had the document been scanned using a scanning operation of the FB type.

Fig.1



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Description

[0001] The present invention relates to an image scanner and, more particularly, it relates to an image scanner having an image correcting function for correcting for differences between two types of image scanning, i.e., a flat bed type and an automatic document feeding type.

[0002] Recently, image scanners have become widely utilized in various fields, for example, communication, business, designs, education, arts, etc. Accordingly, various functions are required in a recent image scanner in order to satisfy a user's request.

[0003] In general, image scanners are available in two types in accordance with the structural difference, i.e., the flat bed (FB) type and the automatic document feeding (ADF) type. The main difference between the FB type and the ADF type lies in that a manuscript is not moved in the former, and the manuscript is moved in the latter when it is read by an image read means.

[0004] It is desirable to provide an image scanner with a correcting function for correcting for a difference between an image output from a flat bed type image scanner and from an automatic document feeding type image scanner.

[0005] According to a first aspect of the present invention, there is provided image scanning apparatus including: an image reading unit, having a light source for directing light onto a document whose image is to be scanned, and also having sensor means for producing electrical signals based on light reflected back from the document; image signal processing means, connected to the said image reading unit, for processing the said electrical signals to derive therefrom image signals representing respectively pixels of the said image; flat-bed scanning means operable to employ the image reading unit to perform a scanning operation of a first type, in which the document is scanned using a flat-bed technique; automatic document feeding scanning means operable to employ the image reading unit to perform a scanning operation of a second type, in which the document is scanned using an automatic document feeding technique; image correction information deriving means operable, in a calibration phase of the apparatus, to cause the apparatus to perform a first comparison scanning operation in which a reference document is scanned using such a scanning operation of one of the said first and second types, and to perform a second comparison scanning operation in which the said reference document is scanned using such a scanning operation of the other of the said first and second types, and also operable to compare the said image signal representing a predetermined comparison pixel of the image as scanned in the first comparison scanning operation with the image signal representing that pixel of the image as scanned in the second comparison scanning operation, and to store image correction information derived from the results of the comparison of the two image signals for the comparison pixel; and image correction means operable when, following the said calibration phase, the apparatus is performing a scanning operation of the same type as the said second comparison scanning operation to cause the image signals derived by the image signal processing means in that operation to be adjusted in dependence upon the stored image correction information so as to reduce differences between those image signals and the image signals that would have been derived had the document been scanned using a scanning operation of the same type as the said first comparison scanning operation.

[0006] According to a second aspect of the present invention, there is provided an image correction method for use in image scanning apparatus that includes: an image reading unit, having a light source for directing light onto a document whose image is to be scanned, and also having sensor means for producing electrical signals based on light reflected back from the document; image signal processing means, connected to the said image reading unit, for processing the said electrical signals to derive therefrom image signals representing respectively pixels of the said image; flat-bed scanning means operable to employ the image reading unit to perform a scanning operation of a first type, in which the document is scanned using a flat-bed technique; and automatic document feeding scanning means operable to employ the image reading unit to perform a scanning operation of a second type, in which the document is scanned using an automatic document feeding technique; which method comprises a calibration step of: performing a first comparison scanning operation, in which a reference document is scanned using such a scanning operation of one of the said first and second types; performing a second comparison scanning operation in which the said reference document is scanned using such a scanning operation of the other of the said first and second types; comparing the said image signal representing a predetermined comparison pixel of the image as scanned in the first comparison scanning operation with the image signal representing that pixel of the image as scanned in the second comparison scanning operation; and storing image correction information derived from the results of the comparison of the two image signals for the comparison pixel; and an image correction step carried out when, following the said calibration step, the apparatus is performing a scanning operation of the same type as the said second comparison scanning operation, in which step the image signals derived by the image signal processing means in that operation are adjusted in dependence upon the stored image correction information so as to reduce differences between those image signals and the image signals that would have been derived had the document been scanned using a scanning operation of the same type as the said first comparison scanning operation.

[0007] In such image scanning apparatus and such

an image scanning method the difference of an image output between the FB type and the ADF type can be eliminated.

[0008] In a preferred embodiment of the present invention, there is provided a correction method in an image scanner having a flat bed type structure and an automatic document feeding type structure, comprising: a white reference portion provided on a glass plate which holds a manuscript; a black reference portion provided adjacent to the white reference portion; a lamp unit for irradiating light onto the manuscript; a mirror for reflecting the light irradiated from the lamp to said manuscript; CCD sensors for converting images on the manuscript to electric signals; the lamp unit, the mirror and the CCD sensors forming an image read unit used commonly in the FB type and the ADF type; and AGC amplifier connected to the CCD sensors for amplifying an output of the CCD sensors and controlling the gain thereof; a microprocessor; a D/A converter for adjusting the gain of the AGC amplifier in accordance with control by the microprocessor; a sample-hold means for sampling an output from the AGC amplifier;

> a white level memory for storing a white reference level which is obtained by reading the white reference portion; a white level D/A converter for converting an analog white reference level signal, which is read from the white level memory, to a digital signal; a black level memory for storing a black reference level which is obtained by reading the black reference portion; a black level D/A converter for converting the analog black reference level signal, which is read from the black level memory, to the digital signal; an A/D converter having an input terminal for receiving the analog signal from the sample-hold means, a white reference terminal for receiving the output from the D/A converter, and a black reference terminal for receiving the output from the D/A converter, and outputting the digital signal; a work RAM for storing various working data; and an E^2PROM for storing resultant data;
> wherein correction of the difference of an image output between the FB type and the ADF type is performed in such a manner that; first, the image read unit of the FB type reads a reference manuscript having uniform reflectance ratio, and a first output of the A/D converter is stored in the work RAM; next, the image read unit of the ADF type reads the same reference manuscript and outputs a second output from the A/D converter; further, a level of the white reference level signal at the white reference terminal of the A/D converter is adjusted by controlling the D/A converter for the AGC which is controlled by the microprocessor so that the second output becomes equal to the first output, and a change rate of the white reference level signal is stored in the E^2PROM when the first output is equal to the second output; and finally, when the image read unit reads the manuscript by using the ADF type, the output from the white level D/A converter is changed in accordance with the change rate which is stored in said E^2PROM.

[0009] In another preferred embodiment, the correction of the difference of the image output between the FB type and the ADF type is performed in such a manner that; first, the image read unit of the FB type reads the reference manuscript having a uniform reflectance ratio, and the first output of the A/D converter is stored in said work RAM; next, the image read unit of the ADF type reads the same reference manuscript and outputs the second output from the A/D converter; further, the gain of the amplifier and sample-hold means is adjusted by controlling the D/A converter used for the AGC which is controlled by the microprocessor so that the second output becomes equal to the first output, and the change rate of the gain is stored in the E^2PROM when the first output is equal to the second output; and finally, when the image read unit reads the manuscript by using the ADF type, the gain of the amplifier and sample-hold means is changed in accordance with the change rate which is stored in the E^2PROM.

[0010] In another preferred embodiment, the correction of the difference of the image output between the FB type and the ADF type is performed in such a manner that; first, the image read unit of the FB type reads the reference manuscript having a uniform reflectance ratio, and the first output of the A/D converter is stored in the work RAM; next, the image read unit of the ADF type reads the same reference manuscript and outputs the second output from the A/D converter; further, the tube current of the lamp is adjusted by controlling a D/A converter for tube current which is controlled by the microprocessor so that the second output becomes equal to the first output, and the change rate of the tube current is stored in the E^2PROM when the first output is equal to the second output; and finally, when the image read unit reads the manuscript by using the ADF type, the tube current of the lamp is changed in accordance with the change rate which is stored in said E^2PROM.

[0011] In still another preferred embodiment, the correction of the difference of the image output between the FB type and the ADF type is performed in such a manner that; first, the image read unit of the FB type reads the reference manuscript having a uniform reflectance ratio, and the first output of the A/D converter is stored in the work RAM; next, the image read unit of the ADF type reads the same reference manuscript and outputs the second output from said A/D converter; further, in accordance with the first and second outputs, a conversion formula is generated so that the first output becomes equal to the second output, and the resultant formula is stored in the E^2PROM; and finally, when the image read unit reads the manuscript by using the ADF type, the output of the A/D converter is changed in

accordance with the resultant formula which is stored in said E^2PROM by using the microprocessor.

[0012] Reference will now be made, by way of example, to the accompanying drawings, in which:

Fig. 1 is a basic block diagram of an image scanner embodying the present invention;
Figs. 2A to 2F are diagrams for use in explaining a normal read sequence from the manuscript when an AGC amplifier is used;
Fig. 3A illustrates the basic structure of an image read unit of the FB type;
Fig. 3B illustrates the basic structure of an image read unit of the ADF type;
Fig. 3C is a diagram for use in explaining the difference in an image output between an FB type reading operation and an ADF type reading operation;
Fig. 4A is a waveform of the image output in an FB type read operation;
Fig. 4B represents a read line on a reference paper of Fig. 4A;
Fig. 5 is a detailed circuit diagram of an A/D converter 16 in Fig. 1;
Fig. 6 is a schematic view for use in explaining correction, by means of a white reference level, between the FB type reading operation and the ADF type reading operation;
Fig. 7 is an explanatory view for explaining correction of a CCD output between the FB type image read unit and the ADF type image read unit; and
Figs. 8A and 8B are flowcharts for use in explaining adjustment processes according to an embodiment of the present invention.

[0013] Fig. 1 is a basic block diagram of an image scanner embodying the present invention. In Fig. 1, reference number 2 denotes a manuscript to be read, 3 a glass plate, 3a a white reference portion, 3b a black reference portion, 4 an image read unit, 5 a lamp, 6 a mirror, and 7 a CCD (charge coupled device) image sensor. Reference numbers 8, 8', 9 and 9' are explained in Fig. 3B, discussed hereinbelow.

[0014] Reference number 10 denotes a lamp inverter, 11 a D/A converter for controlling tube current to the lamp (lamp current D/A converter), 12 an automatic gain control (AGC) amplifier, 13 a D/A converter for a gain control of the AGC amplifier (gain control D/A converter), 14 a sample-hold circuit, 15 a transistor for controlling the tube current to the lamp, 16 an A/D converter, 17 a memory for storing white level (white level memory), 18 a D/A converter for converting white level (white level D/A converter), 19 a D/A converter for converting black level (black level D/A converter), 20 a memory for storing black level (black level memory), 21 a microprocessor, 22 a work memory, and 23 an electrically erasable programmable read only memory (E^2PROM).

[0015] The manuscript 2 is put on the glass plate 3 in the FB type. The white reference portion 3a and the black reference portion 3b are provided inside of the glass plate 3. The lamp 5, the mirror 6 and the CCD sensor 7 are provided in the image read unit 4 which can move freely leftward and rightward under the glass plate 3.

[0016] The light irradiated from the lamp 5 is reflected by the underside of the manuscript 2 or the glass plate 3, and the reflected light is transferred to the CCD image sensor 7 via the mirror 6 (see dotted line). The lamp inverter 10 is provided to convert DC current to AC current so as to produce an AC current the value of which is set by the microprocessor 21. The set AC current from the lamp inverter 10 is supplied to the lamp 5. The AC current set for the lamp current is supplied from the microprocessor 21 through the lamp current D/A converter 11 and the lamp current transistor 15.

[0017] The output of the CCD image sensor 7 is supplied to the AGC amplifier 12. The gain of the AGC amplifier 12 is controlled by the gain control D/A converter 13. The output voltage of the gain control D/A converter is adjusted by the microprocessor 21. The output of the AGC amplifier 12 is supplied to an input terminal IN of the A/D converter 16 after a sample-hold operation by the sample-hold circuit 14.

[0018] The A/D converter 16 has the input terminal IN, a terminal for white reference level (white reference terminal) REFW, and a terminal for black reference level (black reference terminal) REFB. The output of the white level D/A converter 18 is input to the white reference terminal REFW, and the output of the black level D/A converter 19 is input to the black reference terminal REFB. The white level memory 17 can store image data for one line and the black level memory 20 also can store image data for one line. As shown in Fig. 1, the read data from the white level memory 17 is input to the white level D/A converter 18, and the read data from the black level memory 20 is input to the black level D/A converter 19.

[0019] The microprocessor 21 can control the output of the lamp current D/A converter 11, the output of the gain control D/A converter 13, the read/write operations for the white level memory 17 and the black level memory 20, the output of the A/D converter 16, and the read/write operation for the work RAM and E^2PROM through MPU buses.

[0020] Figures 2A to 2F are diagrams for use in explaining a normal read sequence from the manuscript 2 and use of the AGC amplifier. In the drawing, "IN" corresponds to the terminal IN, "REFW" corresponds to the terminal REFW and "REFB" correspond to the terminal REFB in the A/D converter 16. Further, X"FF" corresponds to the the white reference level and X"00" corresponds to the black reference level. Still further, "A" represents the white level, and "B" represents the black level.

[0021] First, the image read unit 4 is moved to the white reference portion 3a in order to read the white ref-

erence level. Next, the gain of the AGC amplifier 12 is adjusted in the following manner. That is first, the white level X"FF" (for example, 255) is input from the whit lev l memory 17 to the white level D/A converter 18. Next, the black level (for example, 0) is input from the black level memory 20 to the black level D/A converter 19. Further, the gain of the AGC amplifier 12 is adjusted in such a way that the output of the A/D converter 16 becomes larger than "0" and smaller than "255" (Fig. 2A). After the gain of the AGC amplifier 12 is adjusted based on the above processes, the output of the A/D converter 16 is sequentially written into the white level memory 17 through the MPU bus (Fig. 2B).

[0022] After the white reference data are written into the white level memory 17, the image read unit 4 is moved to the black reference portion 3b in order to read the black reference level (Fig. 2C). Next, the output of the A/D converter 16 is sequentially written into the black level memory 20 (Fig. 2D). After the black reference data is written into the black level memory 20, the read data of the white level memory 17 is input to the white level D/A converter 18, and the read data of the black level memory 20 is input to the black level D/A converter 19 (Fig. 2E). The read operation for the manuscript is started after the above processes are completed.

[0023] In the read operation for the manuscript (Fig. 2F), when the image signal of the i-th bit of the CCD image sensor 7 is input to the terminal IN of the A/D converter 16, the i-th white reference data of the white level memory 17 is input to the white level D/A converter 18, and the i-th black reference data of the black level memory 20 is input to the black level D/A converter 19.

[0024] In the above explanation, although the gain of the AGC amplifier 12 is adjusted so as to match an input range of the A/D converter 16, it is possible to adjust an amount of the lamp 5 so as to match an input range of the A/D converter 16 instead of gain adjustment.

[0025] Figures 3A to 3C are diagrams for use in explaining a difference of gradation (i.e., a difference of the image output level) between the FB type and the ADF type image scanner. That is, Fig. 3A shows a basic structure of the image read unit of the FB type image scanner, and Fig. 3B shows a basic structure of the image read unit of the ADF type image scanner. Further, Fig. 3C is an explanatory view of the difference of the image output between the FB type and the ADF type.

[0026] In Figs. 3A and 3B, reference 1 denotes a covering member for the manuscript, 3' a glass plate, 8 a drive roller, 8' a sub-drive roller, and 9 a guide member. The same reference numbers as in previous drawings are attached to the same components. In an image scanner embodying the present invention, it is possible to read the manuscript using both the FB type and the ADF type by using only one image read unit 4.

[0027] In Fig. 3A, in the read operation using the FB type, the manuscript 2 is put on the glass plate 3 and the image read unit 4 is moved from the left to the right.

[0028] In Fig. 3B, the sub-rollers 8' are provided at both ends of the guide member 9. In the ADF type, th image read unit 4 is fixedly provided to the left end of the glass plate 3'. The manuscript 2 is inserted between the drive roller 8 and the sub-drive roller 8'. When the drive roller 8 is rotated in the counterclockwise direction, the manuscript is transferred to the left. The light from the lamp 5 is reflected from the underside of the manuscript 2, and the reflected light is transferred to the CCD image sensor 7 via the mirror 6.

[0029] In Fig. 3C, the chain dotted lines show the white reference level. In this case, the left solid line shows the output level of the FB type, and the right solid line shows the output level of the ADF type at the A/D converter 16. Further, the ordinate represents the image output level, and the abscissa represents the time (i.e., distance along the CCD image sensor from one end thereof).

[0030] As is obvious, there is a difference of gradation "d" (i.e., difference of output level) between the FB type and the ADF type. This difference "d" is caused by various factors, for example, the amount of the light reflected from the manuscript, the reflectance ratio of the covering member 1 of the FB type, the gap between the manuscript and the glass plate at the ADF type, the influence of peripheral light, etc.

[0031] In the image scanner which includes the FB type and ADF type, it is necessary to eliminate the difference "d" in order to obtain a high-quality output image.

[0032] In order to eliminate the difference "d" between the FB type and the ADF type, mechanical and electrical methods have previously been considered.

[0033] A first mechanical method, used in the ADF type, is to set the gap between the glass plate 3' and the sub-drive roller 8' as narrow as possible in order to avoid separating the manuscript 2 and the glass plate 3. A second mechanical method, used in the ADF type, is to provide more width (in the left and right direction) along the glass plate 3' in order to obtain better contact between the glass plate 3' and the manuscript 2 so that the amount of the peripheral light at the read position is the same as that in the FB type.

[0034] However, the above two methods have the following problems. In the first method, when the gap between the glass plate 3' and the sub-drive roller 8' is reduced, the thickness of a paper which can be used as the manuscript 2 is limited in order to ensure smooth movement of the paper. In the second method, when the size of the glass plate becomes large, the cost of the image scanner increases. Further, since the movement time for the paper becomes longer, the feeding efficiency of the paper becomes worse.

[0035] One electrical method involves checking (measuring) the difference "d" of the output level between the ADF type and the FB type for several

image scanners, to obtain an average value of the difference of the gradation, and to use the average value to determine a correction value (%) of the white reference value of the ADF type. Further, in the read operation using the ADF type, the above average value is applied to all image scanners, and the white reference level is changed in accordance with the average value in order to eliminate the difference of the image output between the FB type and the ADF type.

[0036] However, in the above electrical method, since the white reference levels for all image scanners are uniformly adjusted by the predetermined correction value, it is difficult to correct a large difference exceeding the average value.

[0037] Image scanning apparatus and methods embodying the present invention aim to eliminate a difference in the image output between the ADF type and the FB type image scanner.

[0038] As shown in Fig. 1, one image scanner embodying the present invention includes: the lamp 5 for irradiating light onto a manuscript 2; the CCD image sensor 7; the AGC amplifier 12 for amplifying the output of the CCD image sensor and controlling the gain thereof by controlling the output voltage of the D/A converter 13 which is controlled by the microprocessor 21; the white level memory 17 for storing the white reference level which is obtained by reading the white reference portion 3a; the white level D/A converter 18 for converting the analog white reference level signal, which is read from the white level memory 17, to the digital signal; the black level memory 20 for storing the black reference level which is obtained by reading the black reference portion 3b; the black level D/A converter 19 for converting the analog black reference level signal, which is read from the black level memory 20, to the digital signal; and the A/D converter 16 having the input terminal IN for receiving the analog signal from the amplifying/sample-hold units 12, 14, 13, the white reference terminal REFW for receiving the output from the D/A converter 18, and the black reference terminal REFB for receiving the output from the D/A converter 19, and outputting the digital signal.

[0039] In the above structure, the lamp 5, the mirror 6 and the CCD image sensor 7 form the image read unit 4 which is used commonly in the FB type and the ADF type.

[0040] In a first embodiment of the present invention, a correction method for correcting the difference of the image output (i.e., difference of the gradation) between the FB type and the ADF type involves the steps described below.

[0041] First, the image read unit 4 of the FB type reads a reference manuscript having uniform reflectance ratio, and a first output of the A/D converter 16 is stored in the work RAM 22.

[0042] Next, the image read unit 4 of the ADF type reads the same reference manuscript and outputs a second output from the A/D converter 16. Further, the level of the white reference level signal at the white reference terminal REFW of the A/D converter 16 is adjusted by controlling the D/A converter 18, which is in turn controlled by the microprocessor 21, so that the second output becomes equal to the first output, and a change rate of the white reference level signal is stored in the E^2PROM 23 when the first output is equal to the second output.

[0043] Finally, when the image read unit 4 reads the manuscript by using the ADF type, the output from the white level D/A converter 18 is changed in accordance with the change rate which is stored in the E^2PROM 23.

[0044] In a second embodiment of the present invention, the correction method involves the steps described below.

[0045] First, the image read unit 4 of the FB type reads the reference manuscript having a uniform reflectance ratio, and the first output of the A/D converter 16 is stored in the work RAM 22.

[0046] Next, the image read unit 4 of the ADF type reads the same reference manuscript and outputs the second output from the A/D converter 16. Further, the gain of the amplifier and sample-hold units 12, 14, 13 is adjusted by controlling the D/A converter 13, which is in turn controlled by the microprocessor 21, so that the second output becomes equal to the first output, and the change rate of the gain is stored in the E^2PROM 23 when the first output is equal to the second output.

[0047] Finally, when the image read unit reads the manuscript by using the ADF type, the gains of the amplifier and sample-hold units 12, 14, 13 are changed in accordance with the change rate which is stored in the E^2PROM 23.

[0048] In a third embodiment of the present invention, the correction method involves the steps described below.

[0049] First, the image read unit 4 of the FB type reads the reference manuscript having a uniform reflectance ratio, and the first output of the A/D converter 16 is stored in the work RAM 22.

[0050] Next, the image read unit 4 of the ADF type reads the same reference manuscript and outputs the second output from the A/D converter 16. Further, the tube current of the lamp 5 is adjusted by controlling the D/A converter 11 which is controlled by the microprocessor 21 so that the second output becomes equal to the first output, and the change rate of the tube current is stored in the E^2PROM 23 when the first output is equal to the second output.

[0051] Finally, when the image read unit reads the manuscript by using the ADF type, the tube current of the lamp 5 is changed in accordance with the change rate which is stored in the E^2PROM 23.

[0052] In a fourth embodiment of the present invention, the correction method involves the steps described below.

[0053] First, the image read unit 4 of the FB type reads the reference manuscript having uniform reflect-

ance ratio, and the first output of the A/D converter 16 is stored in the work RAM 22.

[0054] Next, th image read unit 4 of the ADF type reads the same reference manuscript and outputs the second output from the A/D converter 16. Further, in accordance with the first and second outputs, a conversion formula is generated so that the first output becomes equal to the second output, and the resultant formula is stored in the E^2PROM 23.

[0055] Finally, when the image read unit reads the manuscript by using the ADF type, the output of the A/D converter is changed in accordance with the resultant formula which is stored in the E^2PROM 23 by using the microprocessor.

[0056] In the case of the above first embodiment, for example, it is assumed that the input level of the white reference signal at the white reference terminal (REFW) is "100", and the input level of the black reference signal at the black reference terminal (REFB) is "0". Under the above condition, it is assumed that the first output of the A/D converter 16 when the manuscript 2 is read by the FB type is "50", and the second output of the A/D converter 16 when the manuscript 2 is read by the ADF type is "40".

[0057] In this case, since the first output and the second output are different from each other, the input level of the white reference signal which is input to the A/D converter 16 by the ADF type is adjusted. That is, if the output of the A/D converter 16 becomes "50" when the level of the white reference signal is "80" in the ADF type, the change rate (i.e., 80/100) is stored in the E^2PROM 23. After the above steps, the input level of the white reference signal at the A/D converter 16 in the normal read operation by the ADF type is adjusted to "80/100" of the input level of the white reference signal in the normal read operation by the FB type.

[0058] In the case of the second embodiment, for example, although the same conditions as the first embodiment are given, it is assumed that the input level of the white reference signal at the white reference terminal (REFW) is "100", and the input level of the black reference signal at the black reference terminal (REFB) is given to "0". Under the above condition, it is assumed that the first output of the A/D converter 16 when the manuscript 2 is read by the FB type is "50", and the second output of the A/D converter 16 when the manuscript 2 is read by the ADF type is "40".

[0059] In this case, since the first output and the second output are different from each other, the gain of the amplifier and the sample-hold units is adjusted when the manuscript is read by the ADF type. That is, if the output of the A/D converter becomes "50" when the gain of the amplifier and sample-hold units for the ADF-type reading is "50/40" of the gain of the amplifier and sample-hold units for the FB-type reading, the change rate (i.e., 50/40) is stored in the E^2PROM 23. After above steps, the gain of the amplifier and sample-hold units for the normal read operation by the ADF type is set to "50/40" of the gain of the amplifier and sample-hold units for the normal read operation by the FB type.

[0060] In the case of the third embodiment, for example, although the same conditions as the second embodim nt are given, it is assumed that the input level of the white reference signal at the white reference terminal (REFW) is "100", and the input level of the black reference signal at the black reference terminal (REFB) is "0". Under the above condition, it is assumed that the first output of the A/D converter 16 when the manuscript 2 is read by the FB type is "50", and the second output of the A/D converter 16 when the manuscript 2 is read by the ADF type is "40".

[0061] In this case, since the first output and the second output are different from each other, the tube current flowing in the lamp is adjusted. That is, if the output of the A/D converter 16 becomes "50" when the tube current of the lamp for reading by the ADF type is "50/40" of the tube current for reading by the FB type, the change rate (i.e., 50/40) is stored in the E^2PROM 23. After the above steps, in the normal read operation by the ADF type, the tube current of the lamp is set to "50/40" of the tube current in the normal read operation by the FB type.

[0062] In the case of the fourth embodiment, for example, although the same conditions as the third embodiment are given, it is assumed that the input level of the white reference signal at the white reference terminal (REFW) is "100", and the input level of the black reference signal at the black reference terminal (REFB) is "0". Under the above condition, it is assumed that the first output of the A/D converter 16 when the manuscript 2 is read by the FB type is "50", and the second output of the A/D converter 16 when the manuscript 2 is read by the ADF type is "40".

[0063] In this case, a conversion formula is generated in order to correct the output of the A/D converter 16 as follows.

$$V_{ADF} = \text{an output of the A/D converter} \times 50/40$$

where V_{ADF} is a corrected output.

[0064] In the normal read operation by the ADF type, the output of the A/D converter is corrected based on the above conversion formula, and the resultant data is used as the image output from the A/D converter.

[0065] Figure 4A represents a waveform of the image output in the read operation by the FB type, and Figure 4B represents a read line on a reference paper of Fig. 4A. In Fig. 4A, a chain dotted line denotes the white reference level, and a solid line denotes the amplified output of the CCD image sensor (i.e., output from the sample-hold circuit 14, see Fig. 1). In Fig. 4B the first dot represents the first bit, the center dot represents the i-th bit, and the last dot represents the n-th bit. Further, the point "A" denotes the level of the amplified output of the CCD image sensor at the i-th bit in the vicinity of th center of the paper. In Fig. 4B, the reference paper has

a uniform reflectance ratio.

[0066] Figure 5 is a detailed circuit diagram of the A/D converter 16 of Fig. 1. Reference numbers 22 denote comparators 1 to 256, and reference number 23 denotes a calculation circuit. The upper terminal corresponds to the terminal REFW in the A/D converter and is used to input the white level, the center terminal corresponds to the terminal IN in the A/D converter and is used to input the CCD output through the sample-hold circuit 14, and the lower terminal corresponds to the terminal REFB in the A/D converter and is used to input the black level. Resistors R1 to Rn are connected in series between the terminal REFW and the terminal REFB.

[0067] As shown in the drawing, one input terminal of each comparator 22 is connected to a common node between adjacent resistors, and the other terminal of each comparator 22 is connected in common to the terminal IN of the CCD output. Accordingly, the levels at the terminals REFW or REFB are applied to one input terminal of each comparator through the resistors, and the amplified output of the CCD image sensor is directly applied to the other input terminal of each comparator 22. Further, each output of the comparators 22 is sent to the calculation circuit 23 which outputs the digital signals D0 to D7. These outputs correspond to the output of the A/D converter 16 of Fig. 1.

[0068] The outputs from the A/D converter 16 are determined in accordance with the number of the comparators 22 which are "ON". For example, when all outputs of the comparators 22 are "ON", the output of the A/D converter 16 becomes X"FF" (i.e., white reference level). On the other hand, when all the outputs of the comparators 22 are "OFF", the output of the A/D converter 16 becomes X"00" (i.e., black reference level). As a further example, when the outputs from the first to the 80-th comparators 22 are "ON", the output of the A/D converter 16 becomes X"50".

[0069] As explained above, using an embodiment of the present invention the difference of the image output between the first output by the FB type and second output by the ADF type can be eliminated. Four correction methods embodying the present invention, i.e., correction by means of the white reference level, correction by means of the CCD output, correction by means of an amount of the light produced by the lamp, and correction by means of the conversion formula calculated by the microprocessor will now be explained in detail.

Correction by means of the white reference level

[0070] Figure 6 is an explanatory view for explaining correction by means of the white reference level between the FB type and the ADF type. In the drawing, the chain dotted line denotes the white reference level, and the dotted line denotes the white reference level after correction. Further, the left side denotes the image output by the FB typ , and the right side denotes the image output by the ADF type. In this embodiment, the correction by means of the white reference level is performed as follows.

(1) The image read unit 4 reads the white reference portion 3a, and the read data is adjusted to X"FF" by controlling the D/A converter 18 which is controlled by the microprocessor 21. Similarly, the image read unit 4 reads the black reference portion 3b, and the read data is adjusted to X"00" by controlling the D/A converter 19 which is controlled by the microprocessor 21. Further, the microprocessor 21 controls the D/A converter 13 in order to adjust the gain of the AGC amplifier 12 so that the CCD output is included within the input range of the A/D converter 16.

(2) The image read unit 4 of the FB type reads the reference manuscript having a uniform reflectance ratio. The output level of the A/D converter 16 at the i-th bit has a level A. The level A is stored in the work RAM under the control of the microprocessor 21.

(3) The image read unit 4 of the ADF type reads the same reference manuscript. The output level of the A/D converter 16 at the i'-th bit (i = i') is set to a level B. The level B is stored in the work RAM under the control of the microprocessor 21.

(4) During read operation by the ADF type, movement of the manuscript is temporarily stopped in the vicinity of the center of the manuscript, the microprocessor 21 compares the level A with the level B and adjusts the white reference level of the D/A converter 18 until the level B is equal to the level A.

(5) The change rate of the white reference level is stored in the E^2PROM 23 when the level B is equal to the level A under the control of the microprocessor 21.

(6) In the read operation by the ADF type after the above processes, the white reference level is stored in the white level memory 17, and the white reference level is corrected in accordance with the change rate stored in the E^2PROM 23 by setting the change rate to the D/A converter 18 which is controlled by the microprocessor 21.

Correction by means of the CCD output

[0071] Figure 7 is a view for use in explaining the correction of the CCD output between the FB type and the ADF type. In the drawing, the chain dotted line represents the white reference level, and the dotted line represents the CCD output level after correction. In this embodiment, the correction by means of the CCD output is performed as follows.

(1) The image read unit 4 reads the white reference portion 3a, and the read data is adjusted to X"FF" by controlling the D/A converter 18 which is control-

led by the microprocessor 21. Similarly, the image read unit 4 reads the black reference portion 3b, and the read data is adjusted to X"00" by controlling the D/A converter 19 which is controlled by the microprocessor 21. Further, the microprocessor 21 controls the D/A converter 13 in order to adjust the gain of the AGC amplifier 12 so that the CCD output is included within the input range of the A/D converter 16.

(2) The image read unit 4 of the FB type reads the reference manuscript having a uniform reflectance ratio. The output level of the A/D converter 16 at the i-th bit is set to a level A. The level A is stored in the work RAM under the control of the microprocessor 21.

(3) The image read unit 4 of the ADF type reads the same reference manuscript. The output level of the A/D converter 16 at the i'-th bit (i = i') is set to the level B. The level B is stored in the work RAM under the control of the microprocessor 21.

(4) During read operation by the ADF type, movement of the manuscript is temporarily stopped in the vicinity of the center of the manuscript, the microprocessor 21 compares the level A with the level B and adjusts the gain of the D/A converter 13 until the level B is equal to the level A.

(5) The change rate of the gain is stored in the E^2PROM 23 when the level B is equal to the level A under the control by the microprocessor 21.

(6) In the read operation by the ADF type after the above processes, the white reference level is stored in the white level memory 17, and the gain is corrected in accordance with the change rate of the gain stored in the E^2PROM 23 by setting the change rate to the D/A converter 13 which is controlled by the microprocessor 21.

Correction by means of the amount of light produced by the lamp

[0072] This correction is performed by adjusting the amount of the light produced by the lamp by controlling the D/A converter 11 and the transistor unit 15 under the control of the microprocessor 21. In this embodiment, the correction by means of the amount of the light is performed as follows.

(1) The image read unit 4 reads the white reference portion 3a, and the read data is adjusted to X"FF" by controlling the D/A converter 18 which is controlled by the microprocessor 21. Similarly, the image read unit 4 reads the black reference portion 3b, and the read data is adjusted to X"00" by controlling the D/A converter 19 which is controlled by the microprocessor 21. Further, the microprocessor 21 controls the D/A converter 13 in order to adjust the gain of the AGC amplifier 12 so that the CCD output is included within the input range of the A/D converter 16.

(2) The image read unit 4 of the FB typ reads the reference manuscript having uniform reflectance ratio. The output level of the A/D converter 16 at the i-th bit is set to a level A. The level A is stored in the work RAM in accordance under the control of the microprocessor 21.

(3) The image read unit 4 of the ADF type reads the same reference manuscript. The output level of the A/D converter 16 at the i'-th bit (i = i') is set to the level B. The level B is stored in the work RAM under the control of the microprocessor 21.

(4) During read operation by the ADF type, movement of the manuscript is temporarily stopped in the vicinity of the center of the manuscript, the microprocessor 21 compares the level A with the level B and adjusts the amount of the light by controlling the transistor unit 15 and the D/A converter 11 under the control of the microprocessor 21 until he level B is equal to the level A.

(5) The change rate of the gain is stored in the E^2PROM 23 when the level B is equal to the level A under the control of the microprocessor 21.

(6) In the read operation by the ADF type after the above processes, the white reference level is stored in the white level memory 17, and the amount of the light is corrected in accordance with the change rate stored in the E^2PROM 23 by setting the change rate to the transistor unit 15 and the D/A converter 11 under the control of the microprocessor 21.

Correction by means of the conversion formula

[0073] The output of the A/D converter 16 is sent to the microprocessor 21, and the image output is corrected by using the change rate which is obtained by the correction of the white reference level or the correction of the CCD output.

[0074] For example, when the white reference level is "100" and the black reference level of the A/D converter 16 is "0", it is assumed that the first output is "50" when the manuscript is read by the FB type and the second output is "40" when the manuscript having the same reflectance ratio as above is read by the ADF type. In this case, in the read operation by the ADF type, the output of the A/D converter 16 is multiplied by 50/40 by the microprocessor, and the resultant data is determined as the read image output.

[0075] Figures 8A and 8B are flowcharts for use in explaining adjustment processes according to an embodiment of the present invention.

[0076] In step S1, the white reference level is set to the upper limit value (X'FF') of the input range of the A/D converter 16, and the black reference level is set to the lower limit value (X'00') of the input range of the A/D converter 16 by controlling the D/A converter 18 for the white level and the D/A converter 19 for the black level under the control by the microprocessor 21.

[0077] In step S2, the reference manuscript is put on the glass plate 3, and the gain of the AGC amplifier 12 is adjusted so that the CCD output is included within the input range of the A/D converter by controlling the D/A converter 13 using the microprocessor 21.

[0078] In step S3, the image read unit 4 is moved to the white reference position 3a, and the output of the A/D converter 16 is stored in the white level m_mory 17 as the white reference level under the control by the microprocessor 21.

[0079] In step S4, the image read unit 4 is moved to the black reference position 3b, and the output of the A/D converter 16 is stored in the black level memory 20 as the black reference level under the control by the microprocessor 21.

[0080] In step S5, the image read unit 4 in the FB type starts to read the manuscript.

[0081] In step S6, during the read operation by the FB type, the gradation levels for several bits (e.g. level A for bit i) are stored in the work RAM 22 under the control by the microprocessor 21.

[0082] In step S7, the image read unit 4 in the ADF type starts to read the same manuscript.

[0083] In step S8, during a read operation by the ADF type, movement of the manuscript is temporarily stopped in the vicinity of the center of the manuscript (e.g. at the point corresponding to the bit i at which the level A was obtained during the FB read operation) in order to avoid a read error caused by fluctuation of the paper.

[0084] In step S9, the gradation level (level B) at the temporary-stopping point in the ADF read operation is adjusted so as to become equal to the level A (FB type) by changing one of the following: (a) the white reference level, (b) the gain of the AGC amplifier, and (c) the amount of the light. Alternatively, the adjustment is made by (d) correcting the calculation of the gradation using the conversion formula. The corrected value is stored in the memory, which may be, for example, an E^2PROM.

[0085] In step S10, the manuscript is ejected from the image scanner.

[0086] Now, detailed explanations of (a) to (d) above will be given.

[0087] Regarding (a) above, during a read operation by the ADF type, movement of the manuscript is temporarily stopped at the predetermined position and the image output (i.e., level B) at that position is stored in the work RAM. The microprocessor compares the level B with the level A which is obtained by the FB type. Further, the microprocessor adjusts the white reference level by controlling the D/A converter 18 until the level B becomes equal to the level A.

[0088] Regarding (b) above during a read operation by the ADF type, movement of the manuscript is temporarily stopped at the predetermined position and the image output (i.e., level B) at that position is stored in the work RAM. The microprocessor compares the level B with the level A which is obtained by the FB type. Further, the microprocessor adjusts the gain of the AGC amplifier 12 by controlling the D/A converter 13 until the level B becomes equal to the level A.

[0089] Regarding (c) above, during a read operation by the ADF type, movement of the manuscript is temporarily stopped at the predetermined position and th_ image output (i.e., level B) at the positi_n is stored in the work RAM. The microprocessor compares the level B with the level A which is obtained by the FB type. Further, the microprocessor adjusts the amount of the light of the lamp by controlling the D/A converter 11 and the transistor unit 15 until the level B becomes equal to the level A.

[0090] Regarding (d) above, during a read operation by the ADF type, movement of the manuscript is temporarily stopped at the predetermined position and the image output (i.e., level B) at that position is stored in the work RAM. The microprocessor compares the level B with the level A which is obtained by the FB type. Further, the microprocessor calculates the correction value "C" so that the level B becomes equal to the level A. That is, correction value C can be expressed by $B = C \times A$, where "B" and "A" are levels as mentioned above.

Claims

1. Image scanning apparatus including:

    an image reading unit (4), having a light source (5) for directing light onto a document (2) whose image is to be scanned, and also having sensor means (7) for producing electrical signals based on light reflected back from the document;

    image signal processing means (10 to 21), connected to the said image reading unit (4), for processing the said electrical signals to derive therefrom image signals representing respectively pixels of the said image;

    flat-bed scanning means (1, 3) operable to employ the image reading unit (4) to perform a scanning operation of a first type (FB), in which the document is scanned using a flat-bed technique;

    automatic document feeding scanning means (3', 8, 8', 9) operable to employ the image reading unit (4) to perform a scanning operation of a second type (ADF), in which the document is scanned using an automatic document feeding technique;

    image correction information deriving means (21 to 23) operable, in a calibration phase of the apparatus, to cause the apparatus to perform a first comparison scanning operation in which a reference document is scanned using such a scanning operation of one (FB) of the

said first and second types, and to perform a second comparison scanning operation in which the said reference document is scanned using such a scanning operation of the other (ADF) of the said first and second types, and also operable to compare the said image signal (A) representing a predetermined comparison pixel of the image as scanned in the first comparison scanning operation with the image signal (B) representing that pixel of the image as scanned in the second comparison scanning operation, and to store image correction information derived from the results of the comparison of the two image signals (A, B) for the comparison pixel; and

image correction means (17, 18, 21; 12, 13, 21; 10, 11, 15, 21) operable when, following the said calibration phase, the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation to cause the image signals derived by the image signal processing means in that operation to be adjusted in dependence upon the stored image correction information so as to reduce differences between those image signals and the image signals that would have been derived had the document been scanned using a scanning operation of the same type (FB) as the said first comparison scanning operation.

2. Apparatus as claimed in claim 1, wherein the said image signal processing means (10 to 21) are operable to adjust the said image signal for at least one pixel of the said image relative to a white reference level for the pixel concerned, which white reference level represents a limit value for the image signal that should be obtained when the pixel concerned is maximally white.

3. Apparatus as claimed in claim 2, wherein such a white reference level is set individually for each said pixel of the image along a scan line of the image.

4. Apparatus as claimed in claim 2 or 3, wherein, for the or each said pixel having such a white reference level, that level is set by using the image reading unit (4) to scan a white reference portion (3a) of the apparatus during the said calibration phase, and storing, as the said white reference level, a value derived from the electrical signals produced by the image reading unit (4) during such scanning of the white reference portion.

5. Apparatus as claimed in claim 2, 3 or 4, wherein:

the said image correction information is white reference level correction information which is obtained by storing the said image signal (A) derived for the said comparison pixel in the said first comparison scanning operation and, in the said second comparison scanning operation, determining an adjustment amount by which such a white reference level set for the comparison pixel must be adjusted so as to equalise the said image signal (B) derived for that pixel in the second comparison scanning operation with the stored image signal (A), and storing, as the said white reference level correction information, the determined adjustment amount.

6. Apparatus as claimed in claim 5, wherein:

when the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation, the white reference level set for the or each said pixel is modified in dependence upon the stored white reference level correction information; and

when the apparatus is performing a scanning operation of the same type (FB) as the said first comparison scanning operation, the white reference level set for the or each said pixel is used without such modification.

7. Apparatus as claimed in any one of claims 1 to 4, wherein the said image signal processing means (10 to 21) includes amplifier means (12) connected for amplifying the said electrical signals produced by the said image reading unit (4) and having a gain that is controllable by application thereto of a gain control signal, the image signal processing means further including gain control means (13; 21) for setting the said gain control signal during such a scanning operation;

wherein the said image correction information is gain control correction information that is obtained by storing the said image signal (A) derived for the comparison pixel in the first comparison scanning operation and, in the second comparison scanning operation, determining an adjustment amount by which the gain control signal set by the gain control means must be adjusted so as to equalise the image signal (B) derived for the comparison pixel in the said second comparison scanning operation with the said stored image signal (A), and storing, as the said gain control correction information, the determined adjustment amount.

8. Apparatus as claimed in claim 7, wherein:

when the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation the

gain control signal set by the gain control means (13, 21) is modified in dependence upon the stored gain control correction information; and

when the apparatus is performing a scanning operation of the same type as the said first comparison scanning operation the gain control signal set by the gain control means (13, 21) is used without such modification.

9. Apparatus as claimed in any one of claims 1 to 4, wherein the said image signal processing means include light source control means (10, 11, 15) connected to the said light source (5) for controlling a light output of the light source in dependence upon a light control signal applied thereto, and also include light control means (21) for setting the said light control signal during such a scanning operation;
wherein the said image correction information is light control correction information that is obtained by storing the said image signal (A) derived for the comparison pixel in the first comparison scanning operation and, in the second comparison scanning operation, determining an adjustment amount by which the light control signal set by the light control means (10, 11, 15) must be adjusted so as to equalise the image signal (B) derived for the comparison pixel in the said second comparison operation with the stored image signal (A), and storing, as the said light control correction information, the determined adjustment amount.

10. Apparatus as claimed in claim 9, wherein:

when the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation the light control signal set by the light control means (21) is modified in dependence upon the stored light control correction information; and
when the apparatus is performing a scanning operation of the same type (FB) as the said first comparison scanning operation the light control signal set by the light control means is used without such modification.

11. Apparatus as claimed in any one of claims 1 to 4, wherein:

the said image correction information is image signal correction information that is obtained by storing the said image signal (A) derived for the comparison pixel in the first comparison scanning operation and, in the second comparison scanning operation, determining a difference between the image signal (B) derived for the comparison pixel in the second comparison operation and the stored image signal (A), and storing, as the said image signal correction information, a measure of the determined difference.

12. Apparatus as claimed in claim 11, wherein:

when the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation the derived image signals are modified in dependence upon the stored image signal correction information; and
when the apparatus is performing a scanning operation of the same type (FB) as the said first comparison scanning operation the derived image signals are not subject to such modification.

13. Apparatus as claimed in any one of claims 5 to 12, wherein relative movement between the said reference document and the image reading unit (4) is stopped temporarily during the said second-type comparison scanning operation when the said comparison pixel is being scanned.

14. Apparatus as claimed in any preceding claim, wherein the said first comparison scanning operation is a scanning operation of the said first type (FB), and the second comparison scanning operation is a scanning operation of the said second type (ADF).

15. Apparatus as claimed in any preceding claim, wherein the said image signal processing means are operable to adjust the said image signal derived for at least one of the said pixels relative to a black reference level for the pixel concerned, which level represents a limit value for the image signal that should be obtained when the pixel is maximally black.

16. Apparatus as claimed in claim 15, wherein such a black reference level is set individually for each said pixel of the image along a scan line of the image.

17. Apparatus as claimed in claim 15 or 16, wherein, for the or each said pixel having such a black reference level, the level is set by using the image reading unit (4) to scan a black reference portion (3b) of the apparatus during the said calibration phase, and storing a value derived from the electrical signals produced by the image reading unit during such scanning of the black reference portion.

18. An image correction method for use in image scanning apparatus that includes: an image reading unit

(4), having a light source (5) for directing light onto a document (2) whose image is to be scanned, and also having sensor means (7) for producing electrical signals based on light reflected back from the document; image signal processing means (10 to 21), connected to the said image reading unit (4), for processing the said electrical signals to derive therefrom image signals representing respectively pixels of the said image; flat-bed scanning means (1, 3) operable to employ the image reading unit (4) to perform a scanning operation of a first type (FB), in which the document is scanned using a flat-bed technique; and automatic document feeding scanning means (3', 8, 8', 9) operable to employ the image reading unit (4) to perform a scanning operation of a second type (ADF), in which the document is scanned using an automatic document feeding technique;

which method comprises a calibration step of: performing a first comparison scanning operation, in which a reference document is scanned using such a scanning operation of one (FB) of the said first and second types;
performing a second comparison scanning operation in which the said reference document is scanned using such a scanning operation of the other (ADF) of the said first and second types;
comparing the said image signal (A) representing a predetermined comparison pixel of the image as scanned in the first comparison scanning operation with the image signal (B) representing that pixel of the image as scanned in the second comparison scanning operation; and storing image correction information derived from the results of the comparison of the two image signals (A, B) for the comparison pixel; and
an image correction step carried out when, following the said calibration step, the apparatus is performing a scanning operation of the same type (ADF) as the said second comparison scanning operation, in which step the image signals derived by the image signal processing means in that operation are adjusted in dependence upon the stored image correction information so as to reduce differences between those image signals and the image signals that would have been derived had the document been scanned using a scanning operation of the same type (FB) as the said first comparison scanning operation.

Fig.1

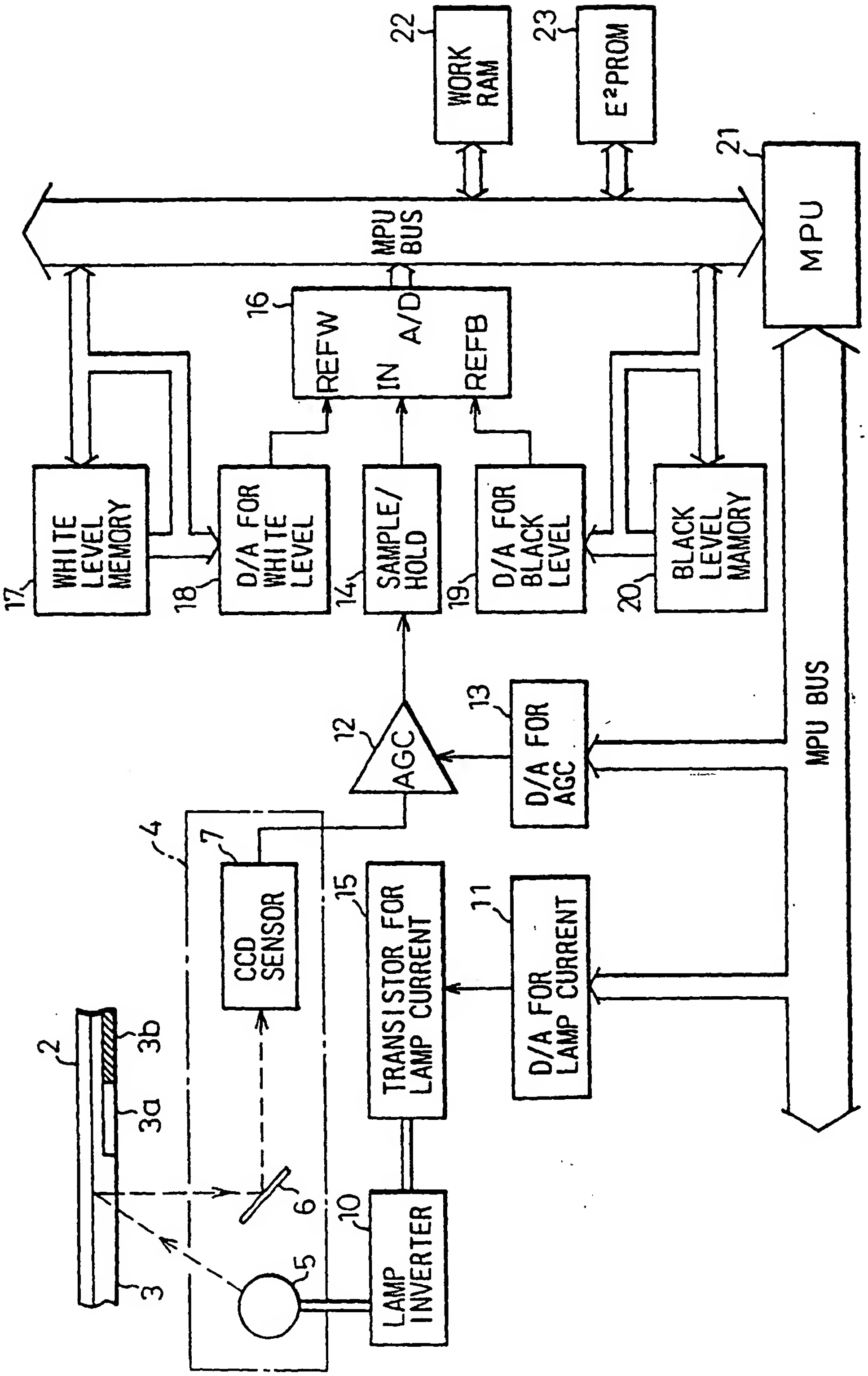

WORK RAM
E²PROM
MPU BUS
MPU
REFW
IN
A/D
REFB
WHITE LEVEL MEMORY
D/A FOR WHITE LEVEL
SAMPLE/ HOLD
D/A FOR BLACK LEVEL
BLACK LEVEL MAMORY
AGC
D/A FOR AGC
MPU BUS
CCD SENSOR
TRANSISTOR FOR LAMP CURRENT
D/A FOR LAMP CURRENT
LAMP INVERTER
2
3
3a
3b
4
5
6
7
10
11
12
13
14
15
16
17
18
19
20
21
22
23

Fig. 2 A

Fig. 2 B

Fig. 2 C

Fig. 2 D

Fig. 2 E

Fig. 2 F

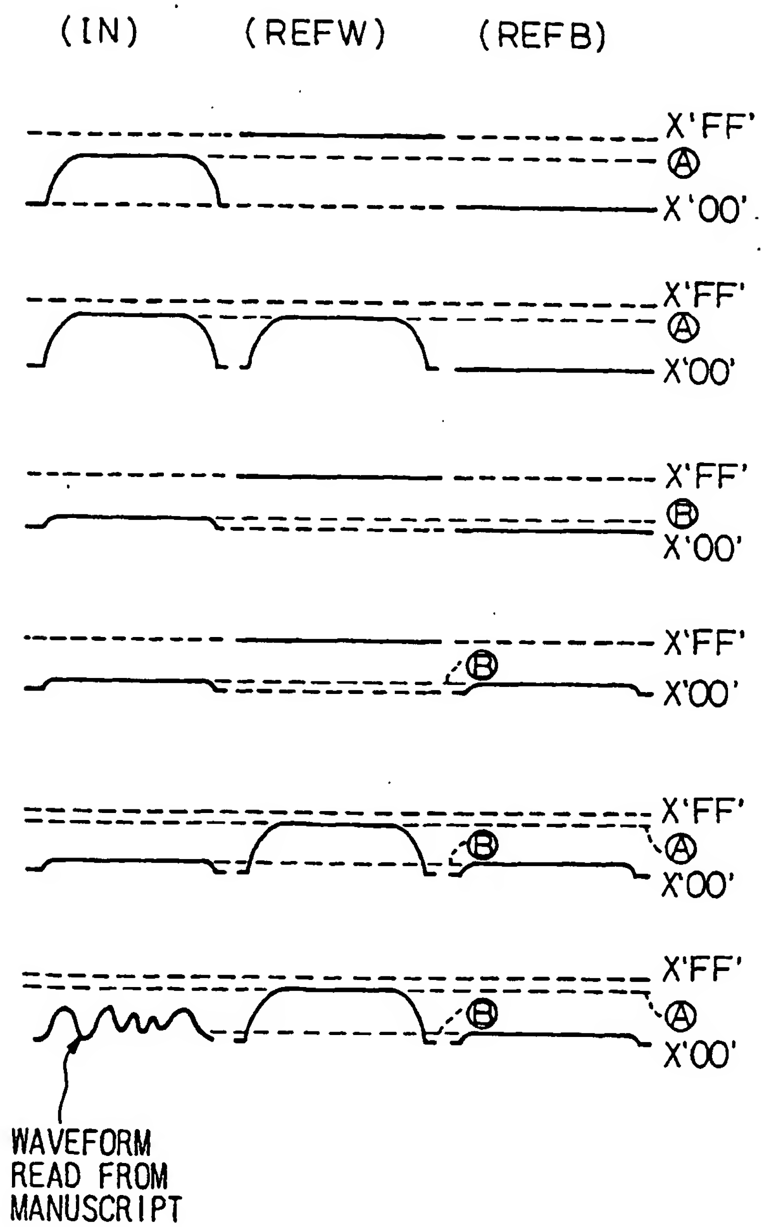


Fig. 3A

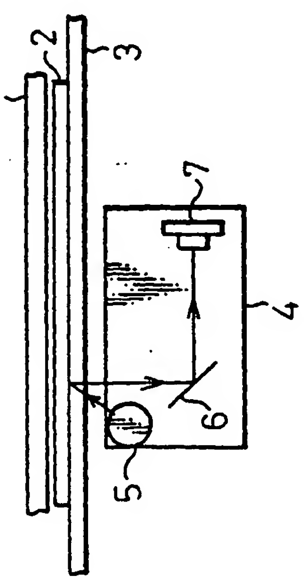


Fig. 3B

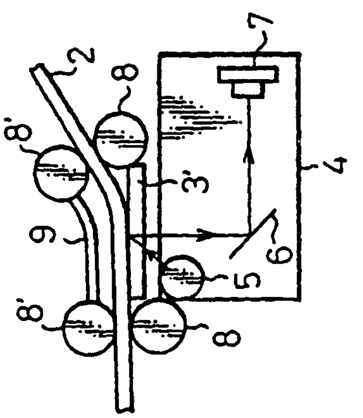


Fig. 3C

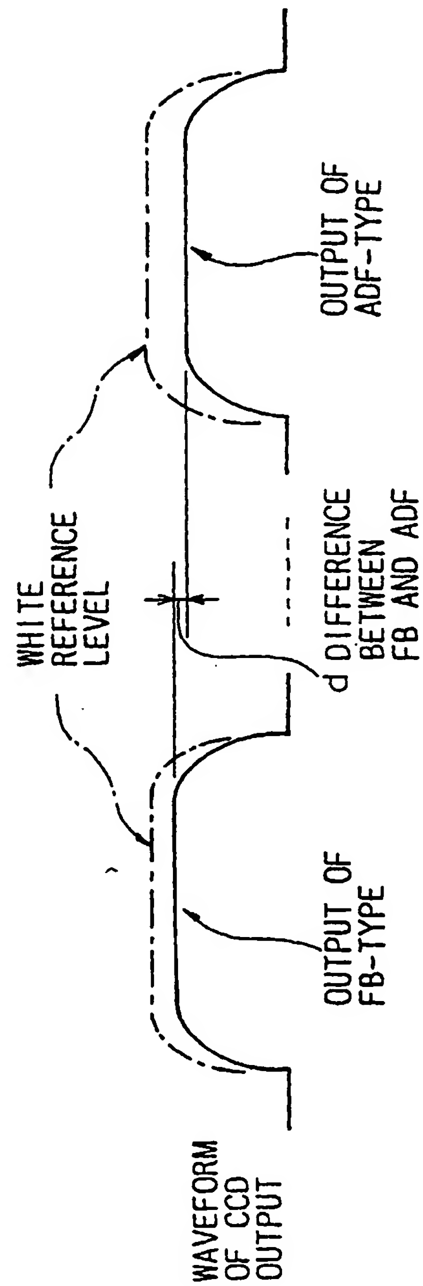


Fig. 4 A

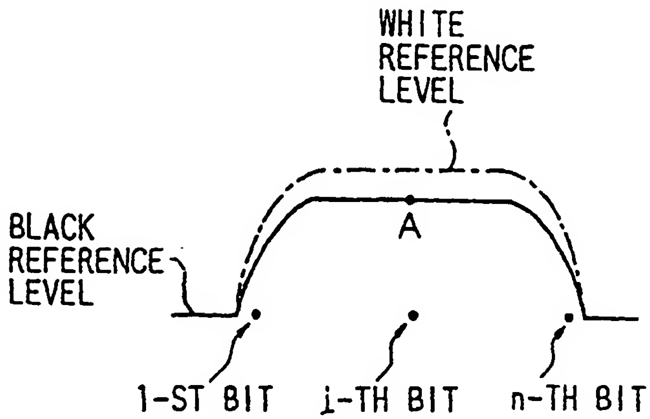


Fig. 4 B

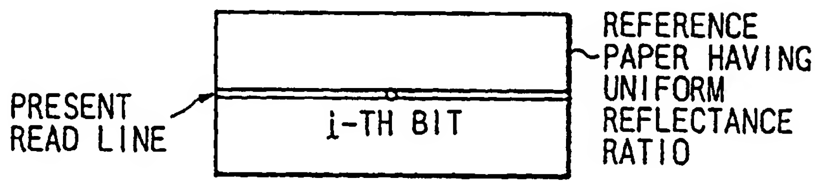


Fig. 5

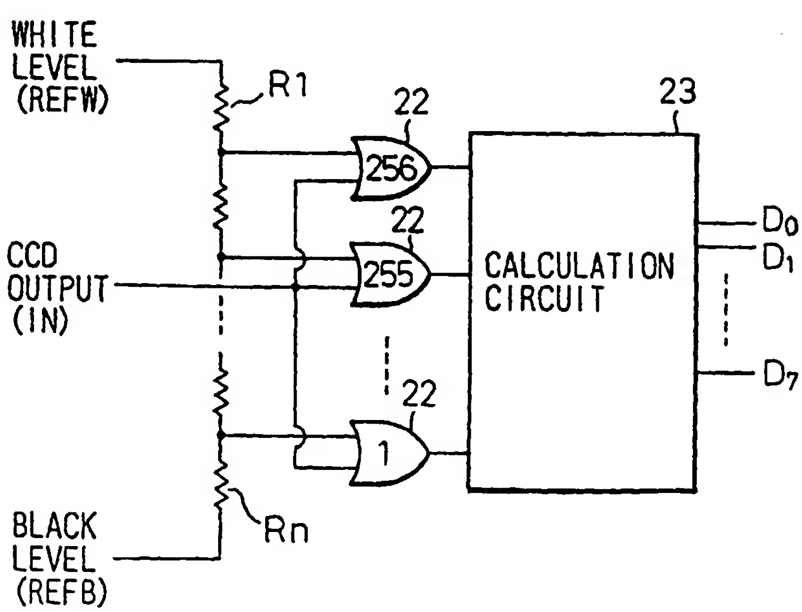


Fig. 6

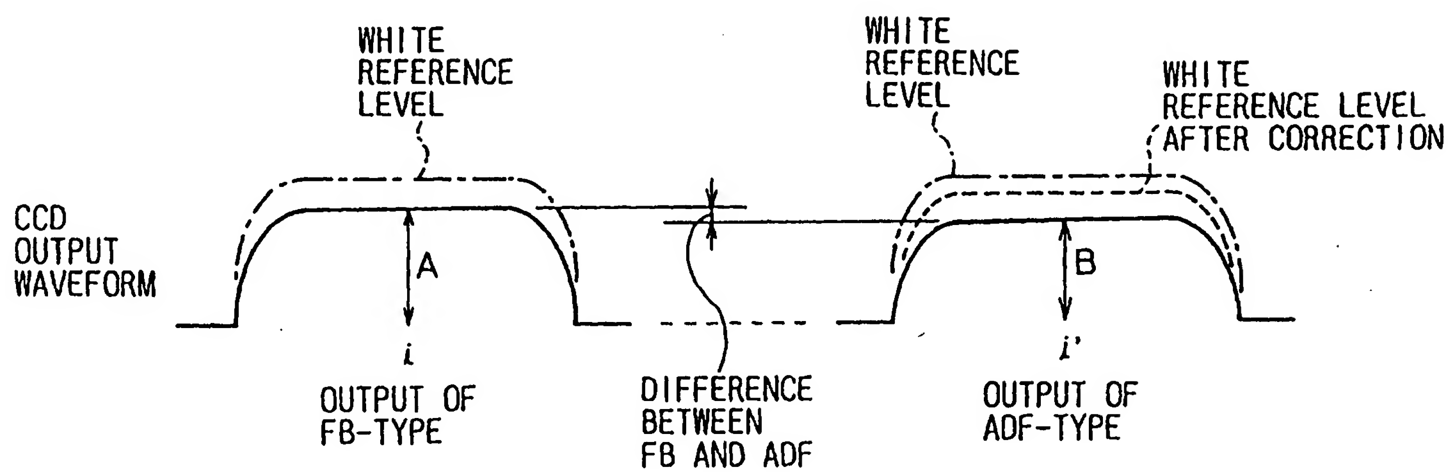

CCD
OUTPUT
WAVEFORM
WHITE
REFERENCE
LEVEL
A
i
OUTPUT OF
FB-TYPE
DIFFERENCE
BETWEEN
FB AND ADF
WHITE
REFERENCE
LEVEL
WHITE
REFERENCE LEVEL
AFTER CORRECTION
B
i'
OUTPUT OF
ADF-TYPE

Fig. 7

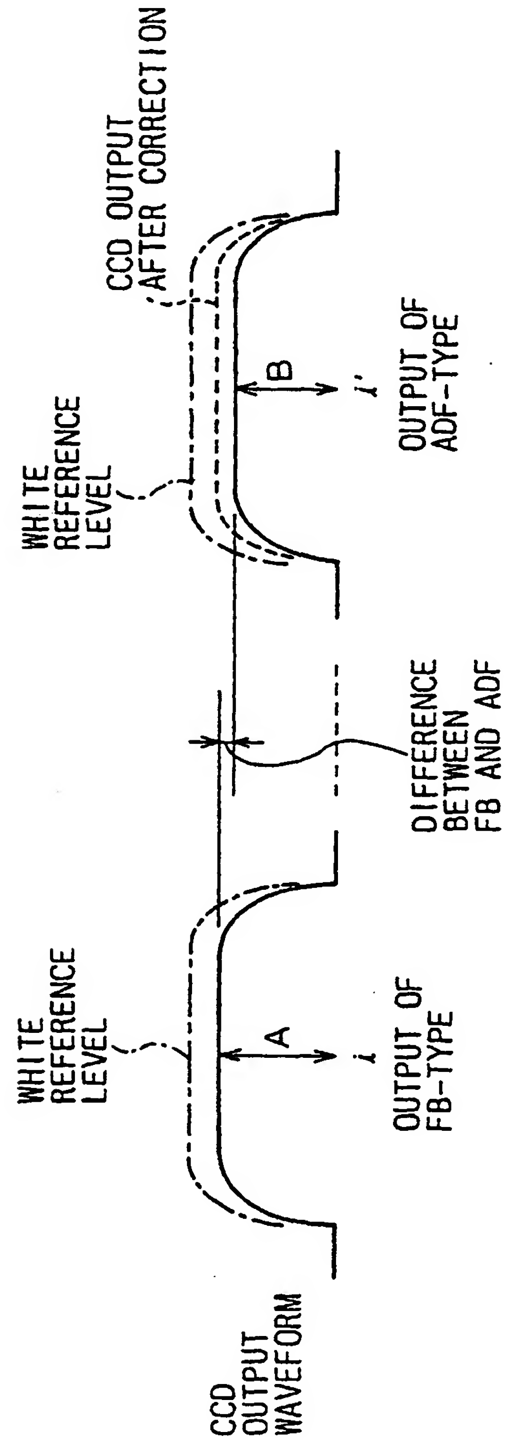

CCD OUTPUT WAVEFORM
WHITE REFERENCE LEVEL
A
i
OUTPUT OF FB-TYPE
DIFFERENCE BETWEEN FB AND ADF
WHITE REFERENCE LEVEL
B
i'
OUTPUT OF ADF-TYPE
CCD OUTPUT AFTER CORRECTION

Fig. 8 A

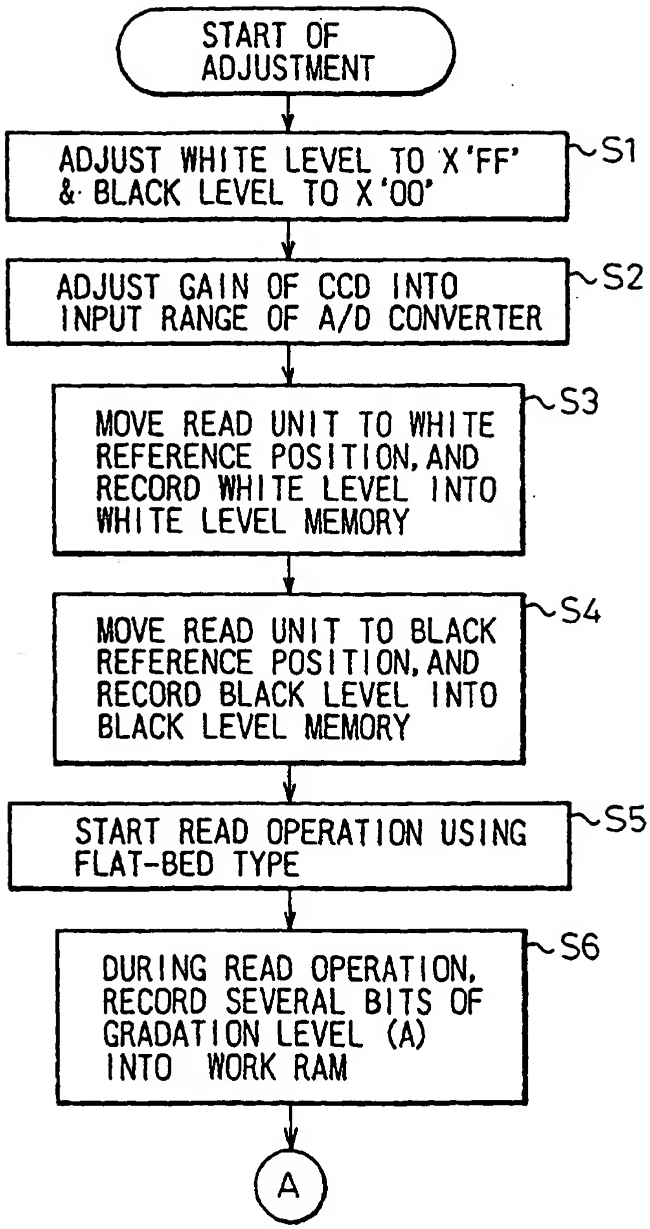
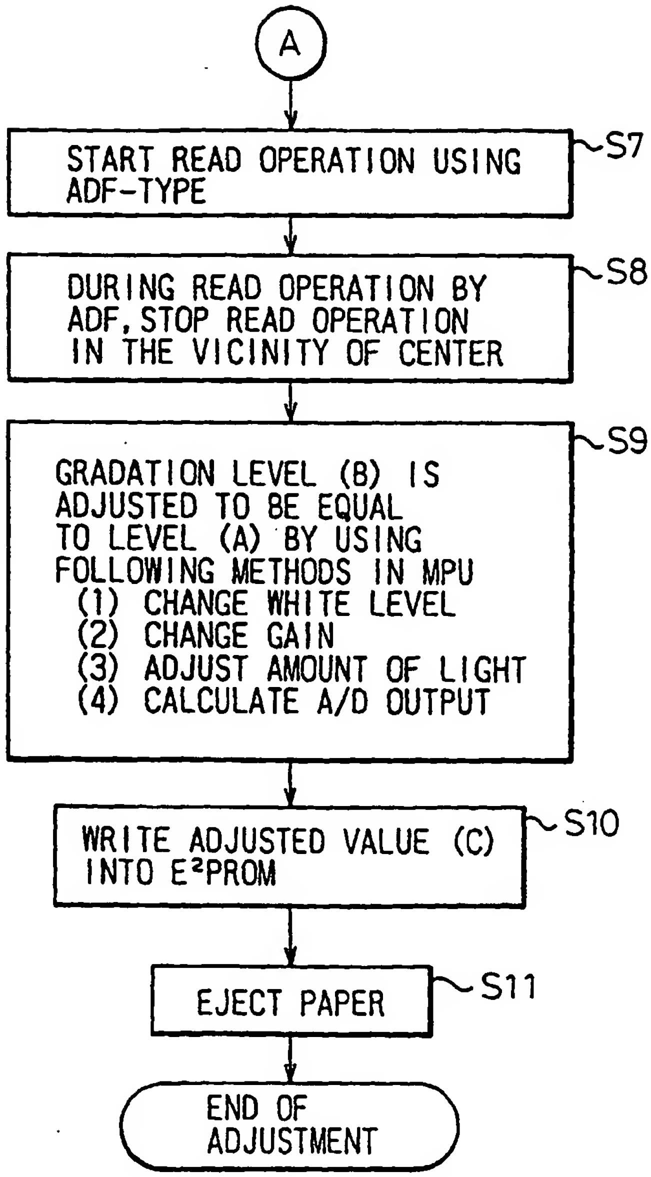

START OF ADJUSTMENT
ADJUST WHITE LEVEL TO X'FF' & BLACK LEVEL TO X'00'
S1
ADJUST GAIN OF CCD INTO INPUT RANGE OF A/D CONVERTER
S2
MOVE READ UNIT TO WHITE REFERENCE POSITION, AND RECORD WHITE LEVEL INTO WHITE LEVEL MEMORY
S3
MOVE READ UNIT TO BLACK REFERENCE POSITION, AND RECORD BLACK LEVEL INTO BLACK LEVEL MEMORY
S4
START READ OPERATION USING FLAT-BED TYPE
S5
DURING READ OPERATION, RECORD SEVERAL BITS OF GRADATION LEVEL (A) INTO WORK RAM
S6
A

Fig. 8 B


A
START READ OPERATION USING ADF-TYPE
S7
DURING READ OPERATION BY ADF, STOP READ OPERATION IN THE VICINITY OF CENTER
S8
GRADATION LEVEL (B) IS ADJUSTED TO BE EQUAL TO LEVEL (A) BY USING FOLLOWING METHODS IN MPU
(1) CHANGE WHITE LEVEL
(2) CHANGE GAIN
(3) ADJUST AMOUNT OF LIGHT
(4) CALCULATE A/D OUTPUT
S9
WRITE ADJUSTED VALUE (C) INTO E²PROM
S10
EJECT PAPER
S11
END OF ADJUSTMENT